# Ch 16 Acids

in most foods → fruit → citric, malic
milk lactic acid
vinegar
soda

Props of acids
↳ 1. Sour taste (lemon - citric acid)

2. Contain H, react w/ metals to release $H_2$ gas
$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

3. Change color of dyes
↳ indicators Ex. litmus (from lichens)

4. React w/ Bases to produce salts + $H_2O$ (neutralize)

5. They are electrolytes.

Arrhenius
Def → comp that ~~donates~~ produces an $H^+$ ion (proton) in aqueous soln (contain H)

$$HNO_3 + H_2O \rightarrow [H_3O]^+ + NO_3^-$$
$(H_2O : H^+)$

→

~~Types of~~ acids (Classification)

Brønsted acids → any sub that donates proton ($H^+$)

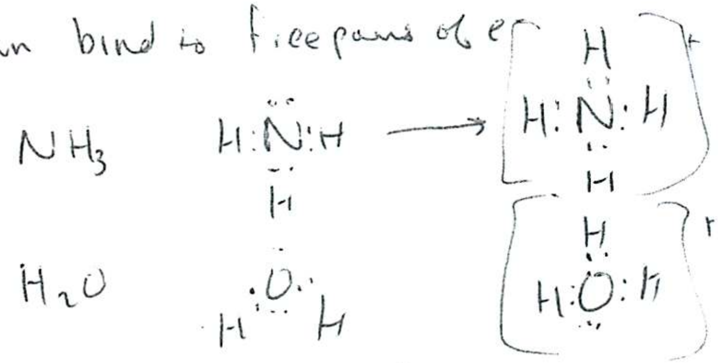
↳ ~~anything the~~

$HNO_3 \rightarrow H^+ \quad NO_3^-$

$HCl \rightarrow H^+ \quad Cl^-$

↳ $H^+ + H_2O \rightarrow H_3O^+$

Protons can bind to free pairs of e⁻



water also proton donor

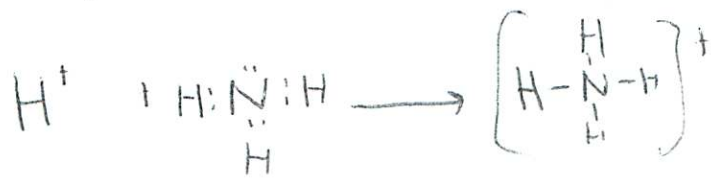
Lewis Acids

↳ avoid def that depends on particular element

role of e⁻ ~~[illegible]~~ pairs

↳ e⁻ pair acceptor → any molecule that ~~[illegible]~~ accepts e⁻ pair to form covalent bond

a proton is a Lewis acid



~~#~~ Hmwk

464 Q1

475 Q2

479 Q1+2

(H 483 Q 1+2)

486 Q 1

AF

488 Q 30 Prob 2, 7, 8

489 Q 9 Prob 5

Ans

H pg 487 6a-f

488 Q 1, 2, 5, 6, 8

~~pg 489~~

489 Q 11, ~~[illegible]~~, 15, 16

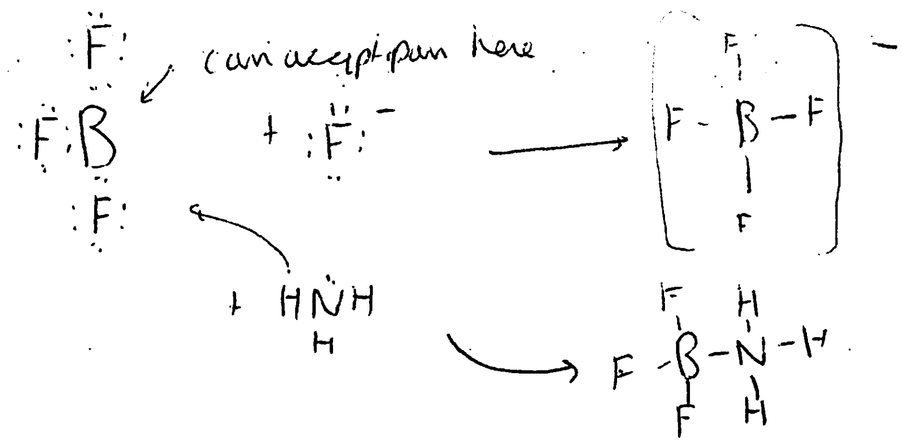
**TABLE 16-7 RELATIVE STRENGTHS OF ACIDS AND BASES**

| Conjugate Acid | Formula | Conjugate Base | Formula |
|---|---|---|---|
| perchloric | $HClO_4$ | perchlorate ion | $ClO_4^-$ |
| hydrogen iodide | $HI$ | iodide ion | $I^-$ |
| hydrogen bromide | $HBr$ | bromide ion | $Br^-$ |
| hydrogen chloride | $HCl$ | chloride ion | $Cl^-$ |
| nitric | $HNO_3$ | nitrate ion | $NO_3^-$ |
| sulfuric | $H_2SO_4$ | hydrogen sulfate ion | $HSO_4^-$ |
| hydronium ion | $H_3O^+$ | water | $H_2O$ |
| hydrogen sulfate ion | $HSO_4^-$ | sulfate ion | $SO_4^{2-}$ |
| phosphoric | $H_3PO_4$ | dihydrogen phosphate ion | $H_2PO_4^-$ |
| hydrogen fluoride | $HF$ | fluoride ion | $F^-$ |
| acetic | $HC_2H_3O_2$ | acetate ion | $C_2H_3O_2^-$ |
| carbonic | $H_2CO_3$ | hydrogen carbonate ion | $HCO_3^-$ |
| hydrogen sulfide | $H_2S$ | hydrosulfide ion | $HS^-$ |
| ammonium ion | $NH_4^+$ | ammonia | $NH_3$ |
| hydrogen carbonate ion | $HCO_3^-$ | carbonate ion | $CO_3^{2-}$ |
| water | $H_2O$ | hydroxide ion | $OH^-$ |
| ammonia | $NH_3$ | amide ion | $NH_2^-$ |
| hydrogen | $H_2$ | hydride ion | $H^-$ |

Increasing Acid Strength ↑ / Decreasing Acid Strength ↓ (acid columns, top to bottom)

Decreasing Base Strength ↑ / Increasing Base Strength ↓ (base columns, top to bottom)

$BF_3$ good Lewis Acid




Types → Strong acids - ionize 100% in aqueous soln

table 16-1 Ex Perchloric, $HClO_4$

$HCl$ $HClO_4$
$HNO_3$
$H_2SO_4$

Hydrochloric $HCl$
Nitric $HNO_3$

all give up 1 proton → $HCl \rightarrow Cl^- + H^+$

↳ monoprotic acid

polyprotic acids → more than 1 proton

diprotic $H_2SO_4 \xrightleftharpoons{+H_2O} HSO_4^+ + H_3O^+ \xrightleftharpoons{H_2O} H_3O^+ + SO_4^{-2}$

~~triprotic~~

Weak acids → weak electrolyte that is an acid

$HSO_4^-$, $HC_2H_3O_2$, $H_2CO_3$, $H_3PO_4$ triprotic

FTDA

Namic acids → Recap

↳ Binary → H + 2nd Element.

↳ add prefix hydro give suffix -ic

HF Hydro flourie acid

IONS

Oxyacids ate-ic ite-ous

Chlorite $ClO_2$ → Chlorous $HClO_2$

Never add water to acid

Go Back over Namings

↳ spatters, heat released

DANGER

16.2 Gen props of Acids - Base Rxns

Props of Bases → 1. Bitter taste
↳ soap

↓ produce $\bar{O}H$

2. Dilute Base soln feel slippery
3. Change color of indicator dyes
4 React w/ acids → make salts + $H_2O$
5 Electrolytes

Def of bases - Arrehenuis - contains hydroxide and produces $\bar{O}H$ in aq soln

$NaOH + ~~H_2O~~ \longrightarrow Na^+ + \bar{O}H$
↳ heat when dissolved

~~Bronsted Base~~

Neutralization Rxn - $H^+ + \bar{O}H$ to form $H_2O$

Example $HCl + NaOH \longrightarrow NaCl + H_2O$

Note everything electrolytic

actual Rxn is

$H^+ + OH^- \longrightarrow H_2O$

$Na^+ + Cl^-$ ← as ions @ start and @ end
↳ spectators

For $H_2SO_{4(aq)} + 2KOH_{(aq)} \longrightarrow K_2SO_{4(aq)} + 2H_2O_{(l)}$

$2H^+ + SO_4^{-2} + 2K^+ + 2\bar{O}H \rightarrow 2K^+ + SO_4^{-2} + 2H_2O$

Bronstead-Lowry Base – proton acceptor

$HCl + \ddot{N}H_3 \rightarrow NH_4^+ - Cl^-$

B-L acid B-L-Base

↳ in a B-L Rxn – protons transferred from acid to the base

Types of Bases → Strong bases any Gr 1 or 2 ion w/ $\bar{O}H$ is a Strong base (but some gr 2 are not as soluble in $H_2O$)

Weak base – $NH_3$, anions

↳ $C_2H_3O_2^- + H_2O \rightarrow HC_2H_3O_2 + \bar{O}H$

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Bronsted Lowry Acid Base Pairs

↳ If a B-L acid gives up proton – now a B-L base (b/c gets a proton.)

$HCl \longrightarrow H^+ + Cl^-$

↑ HCl: BL Acid, acid

↑ $Cl^-$: B-L Base, Conjugate Base

Same goes for a base

$NH_3 + H_2O \rightarrow NH_4^+ + \bar{O}H$ ← conj base

↑ $NH_3$: Base

↑ $H_2O$: acid

↑ $NH_4^+$: conjugate acid

The stronger the acid the weaker the conj base (vice versa. Use HCl to explain)

describe amphoteric w/ $H_2SO_4$

# Ch 17 Titration + pH

Note do this Section in H only + after pH stuff

Consider Rxns

$$HCl + KOH \rightarrow KCl + H_2O$$

1mol 1mol 1mol 1mol

$$\frac{1}{2}H_2SO_4 + KOH \rightarrow \frac{1}{2}K_2SO_4 + H_2O$$

0.5mol 1mol 0.5mol 1mol

b/c $H_2SO_4$ need ½ as much to neutralize KOH

So 1mol HCl + 0.5mol $H_2SO_4$ are chemically equivalent

b/c each supply 1mol $H^+$

equivalent mass of acid → quantity of an acid in (g) that supplies 1mol $H^+$

Calc for HCl + $H_2SO_4$

Same for base - equiv. mass of base - quant of base that supplies 1mol $OH^-$

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| Ch17 HMWK | Prob Set | H Honors |
|---|---|---|
| pg 496 Q 1 | AP pg 517 prob 1 | 517 Prob 1 |
| 505 Q 1,4 | 518 5,9,11,17,21 | 518 Prob 4,7,9,11,16,18 |
| 516 Q 3,4 | 519 Appl Prob 7 | 519 25 |

Normality (Another [ ])

$\frac{\text{\# of equivalents}}{\text{L of soln}}$ → Impotant b/c tells # of equivalents

0.1 N soln HCl same # equiv of 0.1 N $H_2SO_4$

so soln of equal vol = equal # of equiv.

advantage to N: = vol of ~~same~~ diff same soln ~~have~~ w/ same N same # of equivalents

equate M to N   $N = nM$

↑ # of equivalents

do examples from the book

17.2 Aq Soln + pH

Self ionization → water ionizes

$H_2O \rightarrow H^+ + \bar{O}H$

Calculations are $\frac{1 \text{ mol } H^+}{1 \times 10^7 \text{ L } H_2O}$   same for $OH^-$

$[H^+]$ in $H_2O = 1 \times 10^{-7}$ M $= [\bar{O}H]$

$[H^+] = [OH^-]$ means neutral

# pH Scale Relationships


| pH | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $[H_3O^+]$ | 1 | $10^{-1}$ | $10^{-2}$ | $10^{-3}$ | $10^{-4}$ | $10^{-5}$ | $10^{-6}$ | $10^{-7}$ | $10^{-8}$ | $10^{-9}$ | $10^{-10}$ | $10^{-11}$ | $10^{-12}$ | $10^{-13}$ | $10^{-14}$ |
| $[OH^-]$ | $10^{-14}$ | $10^{-13}$ | $10^{-12}$ | $10^{-11}$ | $10^{-10}$ | $10^{-9}$ | $10^{-8}$ | $10^{-7}$ | $10^{-6}$ | $10^{-5}$ | $10^{-4}$ | $10^{-3}$ | $10^{-2}$ | $10^{-1}$ | 1 |

Battery acid

Stomach acid

Apple juice

Black tea

Pure water

Baking soda

Antacid

Hand soap

Household ammonia

Lye

If $[H^+]$ exceeds $1\times10^{-7}$ M acidic

" $[OH^-]$ " " basic

Ex soln $1\times10^{-5}$ M $H^+$ → acid

$1\times10^{-5}$ M $OH^-$ - base

the product of $[H^+][OH^-]$ always constant

↳ depends on temp @ 25°C

$[H^+]\cdot[OH^-] = 1\times10^{-7} M \times 1\times10^{-7} M = \underline{1\times10^{-14} M^2}$.

↑ Refered to $K_w$ ionization const

If one changes the other shifts to allow for same product

↳ Using this rationale if the $[H^+]$ is known the other can be determined

pH scale.

b/c $[H^+][OH^-] = 1\times10^{-14} M^2$

do calculations

$[H^+]$ + $[OH^-]$ as M can be cumbersome exponents get tiring

use $pH = -\log[H^+]$

$\log_{10}$ - power to which 10 is raised to give that #

pure $H_2O$ @ 25°C has $[H^+]$ of $1\times10^{-7}$ M

$pH = -\log(1\times10^{-7} M) = -(-7) = 7$

We will calculate pH from $[H^+ + OH^-]$ + $[H^+]$ + $[OH^-]$ from pH

Calc pH of 0.01 M HCl

↳ Strong acid so 0.01M $H^+$

$-\log(0.01) = \underline{2 = pH}$

Calc pH of 0.01 M NaOH

↳ strong base

1. Calc $[OH^-]$
2. ↳ $[H^+]$.
3. pH

0.01 M $[OH^-]$ since $\underline{pH}$ need ph

$[H^+][0.01M] = 1\times10^{-14} M^2$

$[H^+] = 1\times10^{-12} M = \underline{pH\ 12}$

if not @ a 1 use log anyway

Do Reverse Calculation.

pH of HCl soln is 2.4 what is [H⁺], [HCl]

pH 2.4 → antilog(-2.4) = 0.00398 M $H^+$ → 0.00398 M HCl

pH of NaOH = 12.2 what is [$OH^-$], [NaOH]

pH 12.2 → antilog(-12.2) = $6.31 \times 10^{-13}$ M $H^+$

↑ leads to [$H^+$]

$[OH^-] = \frac{1 \times 10^{-14} M^2}{H^+}$ → 0.016 M $OH^-$

0.016 M NaOH

For weak species use % dissociation

3 M $HC_2H_3O_2$ (5% dissociate) [$H^+$] = 0.15 M → pH = 0.82

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Titration Rxn between acids + bases

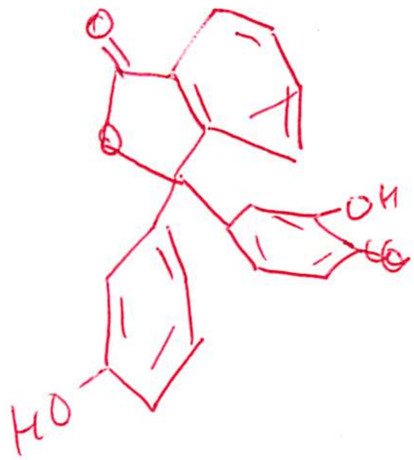
$HA + BOH \rightarrow AB + H_2O$

↳ provides sensitive means of determining relative volumes of acidic + basic soln that are equivalent

Def → the controlled addition and measurement of the amount a soln of known [ ] req. to react completely w/a measured amount of a soln of unknown [ ]

Eq-pt - point a which 2 solns used in titration are in chemically equivalent amounts

# Titration




Phenolphthalein

As discussed previously Titration ~~has~~ is the determination of ~~knowledge discovery of standard soln~~ an solution [ ] from a known [ ].

Used in neutralization Rxns to determine acid or base [ ]'s.

basically when ~~Mol A = mol B pH is basically neu~~

3 types → 1. Strong acid / Strong Base

Eq pt @ pH 7.

Means that mol $H^+$ = mol $OH^-$

for example → $NaOH + HCl \rightarrow NaCl + H_2O$ (↓ Not acid/base salt)

2. Weak acid / Strong Base

Eq Pt above 7 why look @ Rxn

$HC_2H_3O_2 + NaOH \rightarrow NaC_2H_3O_2 + H_2O$

↓

$C_2H_3O_2^- + H_2O \rightarrow {}^-OH$ ← Basic

3 for Strong Acid/Weak Base ~~indicator~~
Eqpt below 7

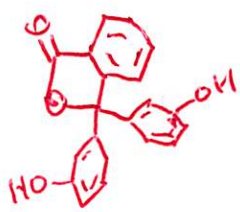
$NH_4OH + HCl \rightarrow NH_4Cl + H_2O$

$NH_4^+ + H_2O \rightarrow NH_4OH + H^+$ ← Acid

So since eq pts are different different indicators are very important.

Choose indicators wisely!

Indicators themselves are weak acids




$HIn \rightleftharpoons H^+ + In^-$

diff. colors

for phenolphthalein – show x-tene.

HIn is Clear

$In^-$ Red/Pink

In acid soln HIn most common b/c

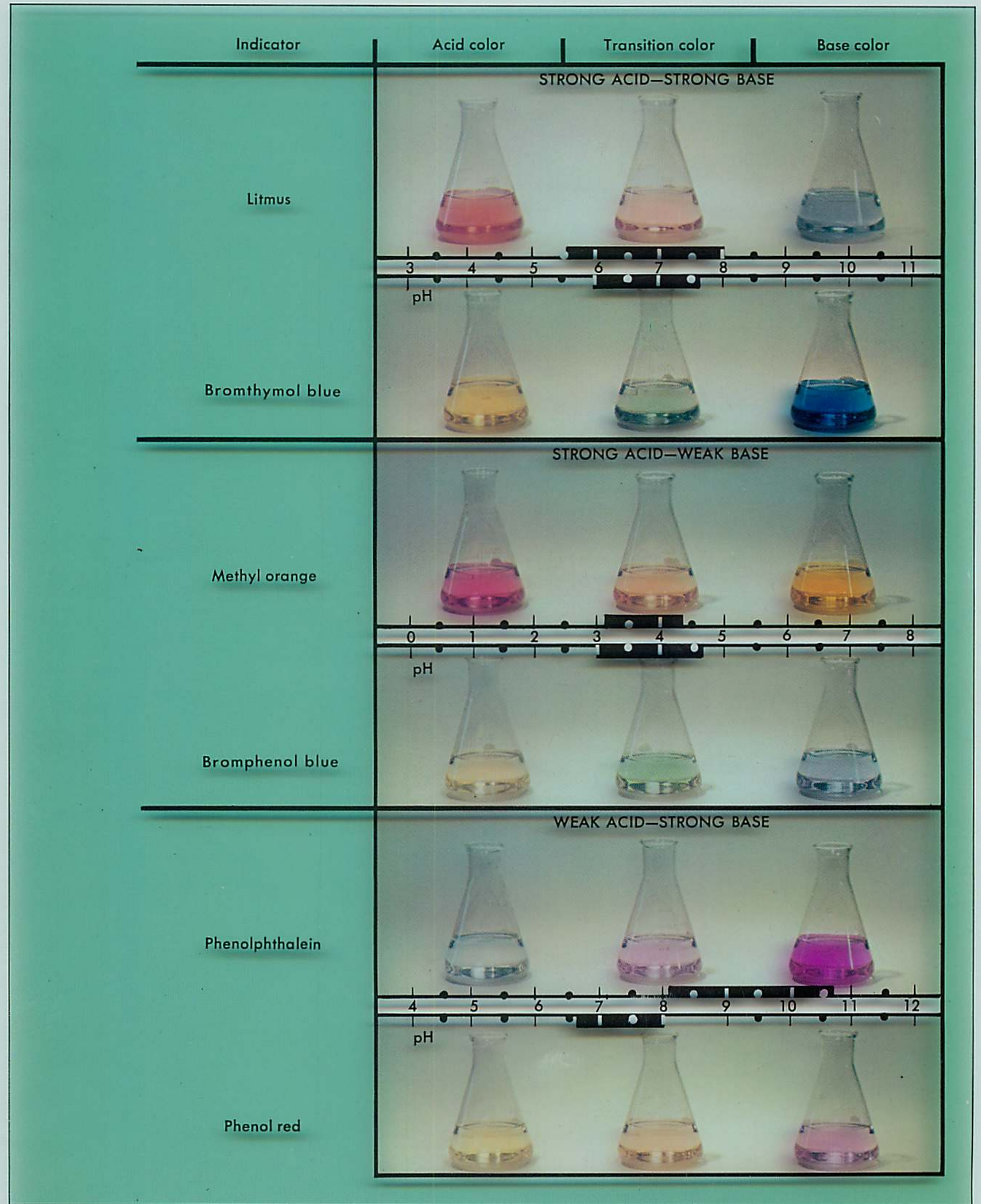
$In^- + H^+ \rightleftharpoons HIn$

high[ ] (Eq)

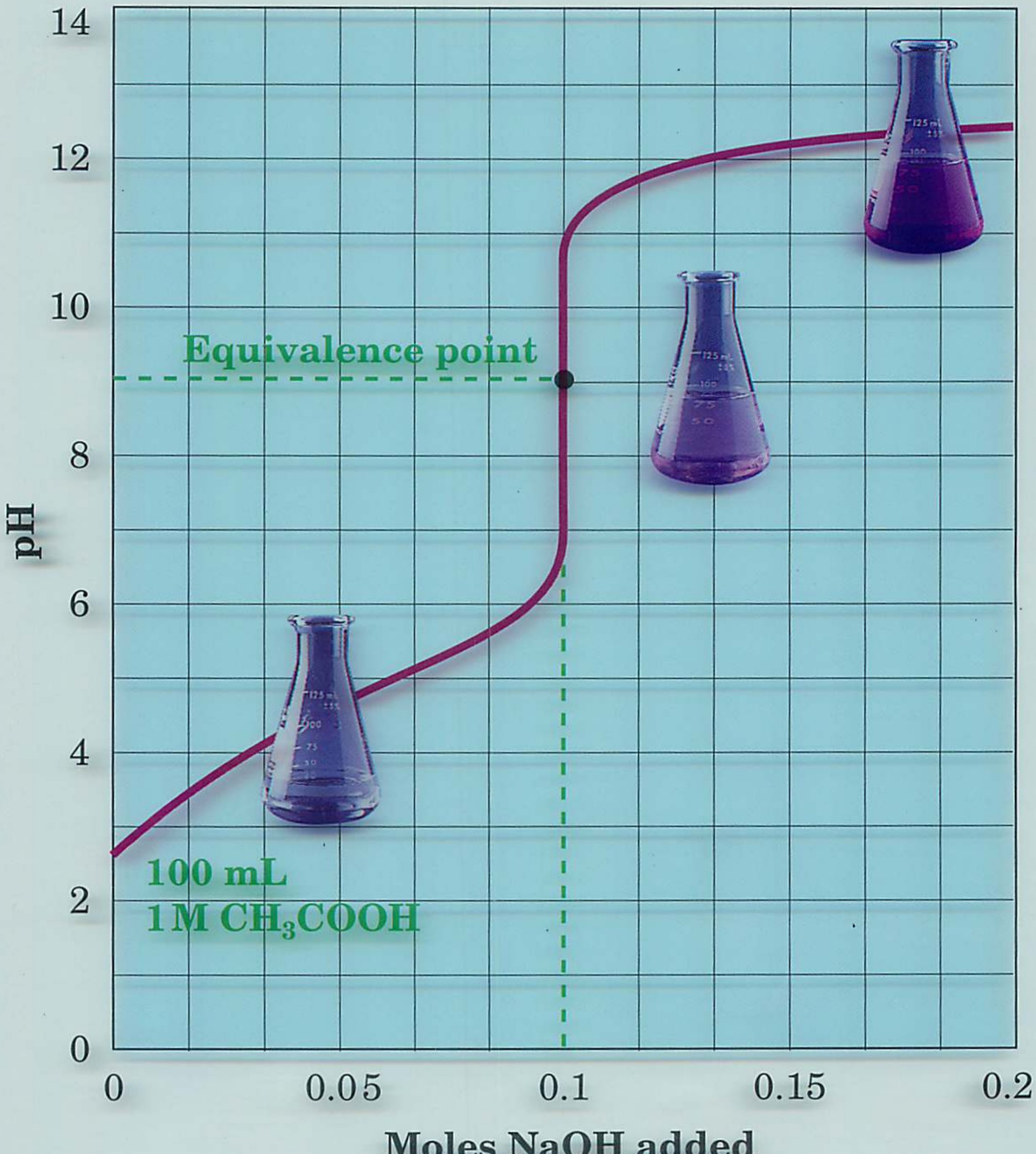
In basic soln $HIn + OH^- \rightleftharpoons In^- + H_2O$

Δ color @ lower pH levels b/c some are stronger acids

# 36 Acid-Base Indicators



# Titration Curve for a Weak Acid and a Strong Base



# Titration Curve for a Strong Acid and a Strong Base